

A Management Guide

for

Northern Hardwoods

in New England

by

Adrian M. Gilbert and Victor S. Jensen

STATION PAPER NO. 112 • NORTHEASTERN FOREST EXPERIMENT STATION • 1958
FOREST SERVICE • U.S. DEPARTMENT OF AGRICULTURE • UPPER DARBY, PA.

RALPH W. MARQUIS, DIRECTOR

The Authors

ADRIAN M. GILBERT *had his professional training at the University of Michigan and the Swiss Federal Institute of Technology, Zurich, Switzerland. He joined the U. S. Forest Service in 1946 and served for a while in the Forest Survey of the Northeast. Since 1952 he has been engaged in research in the silviculture and management of northern hardwood forests, and is leader of the northern hardwoods project at the Northeastern Forest Experiment Station's research center at Laconia, New Hampshire.*

VICTOR S. JENSEN *had his professional training at the University of Minnesota and the Yale Forestry School, and spent several years in administrative work with the U. S. Indian Service and the U. S. Forest Service in Oregon, Washington, Idaho, and Utah. Except for 2 years as War Production Board lumber advisor for New Hampshire during World War II, he has served with the Northeastern Forest Experiment Station continuously since 1929, mainly in research in management of northern hardwoods. He is in charge of the Experiment Station's research center at Laconia, New Hampshire.*

**A Management Guide
for Northern
Hardwoods
in New England**



by Adrian M. Gilbert and Victor S. Jensen

*Northeastern Forest Experiment Station
Forest Service, U.S. Dept. Agriculture*

Contents

- 1 ● The northern hardwoods in New England
- 3 ● Some characteristics of the northern hardwoods
 - Species*
 - Sites*
 - Old growth*
 - Second growth*
- 4 ● Old-growth forest
 - Silvicultural systems*
 - Selection system cutting*
 - Patch cutting*
 - Clear cutting*
 - Stocking, structure, and growth*
 - High-value products*
 - Bulk products*
- 14 ● Second-growth forest
 - Silvicultural systems*
 - Clear cutting*
 - Selection system cutting*
 - Tending the stands*
 - Cleanings*
 - Thinnings*
 - Rotation and stocking*
 - High-value products*
 - Bulk products*
- 20 ● General remarks
- 21 ● Literature cited

The Northern Hardwoods in New England

NORTHERN HARDWOOD forests occupy about 9 million acres of land in New England. In recent years, these hardwood forests have made increasing contributions to the economy of this region. Their future management should be even more rewarding.

This guide has been prepared for use in managing the old-growth and second-growth northern hardwoods of New England. It is intended to help chart the course of management for the initial cutting cycles on previously unmanaged forests. The suggestions presented summarize the results of 25 years of research on the Bartlett Experimental Forest, Bartlett, New Hampshire, and elsewhere in the region.

Table 1.--Some characteristics of northern hardwood species in New England¹

Species	Tolerance	Response	Growth rate	Management objective	Risk	Reproduction
Sugar maple	Very tolerant	Responds well to thinning or release.	Moderate to fast	18-24" d.b.h.	Healthy tree. May be deformed by maple borer.	Pole trees sprout vigorously. Seeds every 3-7 years.
American beech	Very tolerant	Responds well to thinning or release.	Moderate	14-20" d.b.h.	Poor risk because of Nectria. Subject to frost and sunscald damage.	Abundant root suckering. Seeds every 2-3 years.
Yellow birch	Intermediate	Fair response to early thinnings.	Slow	18-24" d.b.h.	Sensitive to high soil temperature and sudden exposure. Dieback and post-logging decadence.	Poles sprout. Seeds every 1-2 years.
Paper birch	Intolerant	Responds to early thinning.	Fast	60-70 years	Sensitive to sudden opening and high soil temperature. Dieback and post-logging decadence.	Seeds most years. Moderate stump sprouting.
White ash	Intolerant	Responds to early thinning.	Moderate to fast	14-18" d.b.h. 70-80 years	Healthy tree.	Seeds every 3-5 years.
Red maple	Intermediate	No need to thin.	Moderate to fast	14-20" d.b.h.	Sprouts often butt-rotted. Subject to black heart.	Sprouts vigorously. Seeds almost every year.
Aspen	Intolerant	No need to thin.	Fast	40-50 years	Rots easily. Large-tooth aspen is the better species.	Abundant root suckering. Seeds 4-5 years.
Red spruce	Very tolerant	Responds to thinning or release.	Slow to moderate	12-18" d.b.h.	Shallow rooted.	Seeds 3-8 years.
Eastern hemlock	Very tolerant	Responds very well to release.	Moderate to fast	16-22" d.b.h.	Larger trees subject to ring shake.	Seeds 2-3 years.

¹In preparing this list, it was assumed that the trees are found under favorable growing conditions, such as site and stocking, for the species.

Some Characteristics of the Northern Hardwoods

SPECIES

K EY SPECIES in the northern hardwood forest are yellow birch (*Betula alleghaniensis*), beech (*Fagus grandifolia*), and sugar maple (*Acer saccharum*). These three species may occur together as a nearly pure forest type, or they may be associated with hemlock (*Tsuga canadensis*), red spruce (*Picea rubens*), paper birch (*Betula papyrifera*) white ash (*Fraxinus americana*), red maple (*Acer rubrum*), or aspen (*Populus tremuloides* and *P. grandidentata*). Younger stands that have followed fire or clear-cutting, or that have seeded in abandoned pastures, often contain large proportions of paper birch, ash, red maple, and aspen as a cover type.

In the management of these forests, the characteristics of the principal species (those that affect their response to cultural treatments) should be considered (table 1).

SITES

In New England, northern hardwood sites occur up to elevations of about 2,000 feet, on land that is rolling to mountainous. The river valleys below the hardwoods are usually occupied by white pine types in the southern part of the region and by spruce and fir types farther north. In the mountains, spruce types grow above the hardwoods.

On hardwood sites, the land is usually stony. Most soils are podzols or brown podzolics derived from glaciated granites and schists. A few soils have developed wholly or in part from limestone and have better structure and greater fertility than the podzols. The most productive but least common soils are deep, well drained to moderately well drained, and of medium texture.

OLD GROWTH

The typical old-growth northern hardwood forest of today has a history of some cutting about the turn of the century (fig. 1). The first cutting usually took all of the softwood sawtimber. Later, the better hardwoods were cut. The larger trees that remain are often overmature and of low value in terms of species or quality. The smaller sawtimber trees were present but unmerchantable during those earlier operations; saplings and poles came in later. Since then, the stands may have been untouched.

In these old-growth forests, cull--in completely useless trees and portions of merchantable trees--usually amounts to a third of the gross volume. Growth commonly is slow, and the trees vary considerably in quality. The stands are most often uneven-aged, usually with gaps in some diameter classes and excesses in others. Trees range in size from saplings to more than 30 inches d.b.h. Seedlings of tolerant species, such as sugar maple and beech, are abundant.

SECOND GROWTH

Second-growth forests are more or less even-aged. Where areas have been truly clear-cut for charcoal or fuelwood, or burned over, there is a narrow range of ages and diameters. Other areas have only been heavily high-graded. While the proportion of even-aged trees is high in these stands, there is a scattering of large old cull or wolf trees.

Old-Growth Forest

THE old-growth forest usually will be managed under an uneven-aged silvicultural system, but some stands within the forest may be treated differently. Timber markers will keep in mind not only the stocking, structure, and growth goals outlined in a later section but also current realities such as costs and selling prices. The recommendations that follow are similar to those proposed earlier by



Figure 1.--An old-growth stand of northern hardwoods in the White Mountains. The better quality trees were cut about 60 years ago.

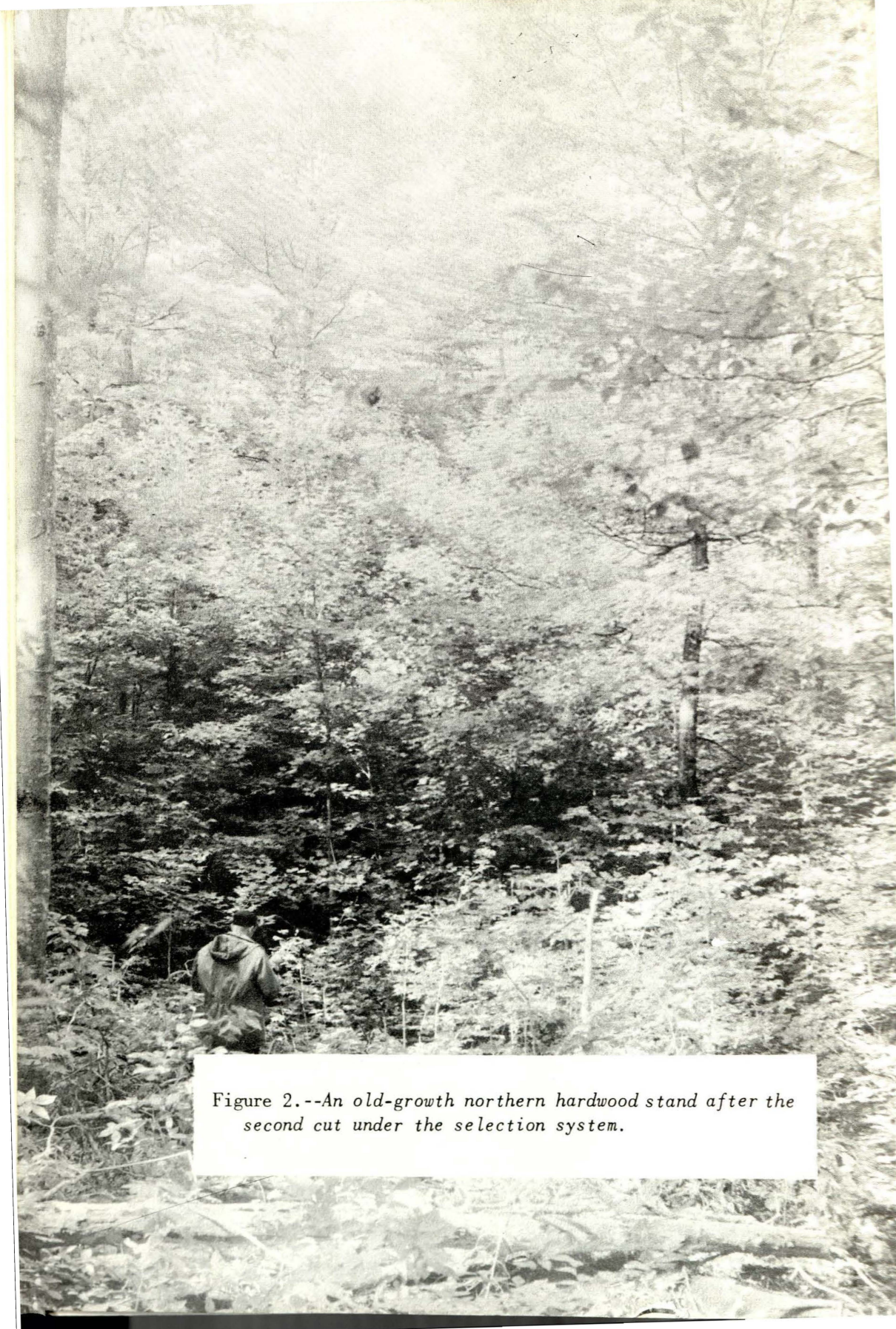


Figure 2.--An old-growth northern hardwood stand after the second cut under the selection system.

Jensen (.3). In application, the forester may want to alter these recommendations in line with his own experience, the wishes of the property owner, and local growing and marketing conditions.

SILVICULTURAL SYSTEMS

Selection

System Cutting

Since past cutting operations have downgraded the growing stock, most stands that are to become part of a balanced, uneven-aged forest need a thorough renovating when management is started. Nearly always, there is so much poor growing stock that the first cut should be moderately heavy, taking 25 to 40 percent of the gross volume in trees 5.0 inches d.b.h. and larger. Removal of more than 40 percent of the gross volume is not usually advisable, as the shock might cause some trees, such as yellow birch, to die. Others, as well as yellow birch, would tend to feather out and lose value.

The first cut or cuts are primarily for presalvage and improvement. And because most of the trees fall into one or more groups of undesirable growing stock, in a sense, they "mark themselves". These groups are:

- Trees that may die before the next cut.
- Trees of low quality and vigor.
- Less desirable species.
- Multiple stems.
- Merchantable paper birch and aspen, particularly at maturity.

The silvicultural requirement is that the first cut should, as stated, be moderately heavy (fig. 2). If the distribution of diameters is distorted, either by cutting or other factors, it will take longer to reach the goal of a balanced structure. In general, any cutting under the selection system has the combined objectives of thinning, presalvage, and harvest cutting. This is especially true of first cuts in previously unmanaged forests. This combination of objectives in one cut gives flexibility in marking, but requires much silvicultural skill.

Strict application of the tree selection system will perpetuate or increase the proportions of the very tolerant species--sugar maple, beech, hemlock, and red spruce.

A primary objective in any system of moderate cutting is improvement of the residual stand. Thus, the removal of cull trees and wolf trees from growing stock is important. The value of a moderate cut cannot materialize without disposal of this inferior growing stock. This can be removed in several ways. Sales contracts may include provisions for felling certain cull trees and actual or potential wolf trees. Or, these trees may be girdled or treated with silvicides after the cutting is done.

The selection system is best for those stands where:

- Most trees to be removed occur singly rather than in groups.
- There are ample markets for the very tolerant species.
- The trees reserved for future growth cover a wide range of sizes and show promise of maintaining or increasing their value.

Patch Cutting

Patch cuttings are clear-cuttings of small areas, usually less than $2/3$ acre. Those trees within a patch that are not harvested are girdled or poisoned, including saplings down to 2 inches.

In many old-growth stands, trees that would be selected for cutting occur in clumps or groups. These could be the nuclei of patches. To decide if they should be enlarged to patch size, weigh the present and future values of the additional trees that would be cut against the need for reproduction of the less tolerant species--yellow and paper birch.

At the Bartlett Experimental Forest, yellow birch has reproduced very well on patches up to $1/3$ acre. Regeneration of paper birch has been promising on patches of $1/3$ to $2/3$ acre. In laying out patches, we try to avoid leaving yellow birch exposed to the south and west (north and east side of patch) because it is very sensitive to sudden temperature changes.

Clear Cutting

In old-growth forest, some areas may not contain enough valuable or potentially valuable stems to hold over for another cut. These areas should be clear-cut, including complete removal of saplings and cull trees (fig. 3). Regeneration after such cutting usually is good, comprising both advance reproduction and new seedlings and sprouts. Paper birch, yellow birch, and aspen typically appear in the new regeneration in greater proportion than in the previous stand.

On both patch and clear-cuttings, there are small unmerchantable trees as well as large cull trees that should be removed. As in the selection system, these could be felled during logging. Or, they could be girdled or treated with silvicides soon after.

In the typical old-growth forest, there is often a need for all three methods of cutting--selection, patch, and clear-cutting. For a given area within the forest, the choice depends upon the condition of the standing trees and

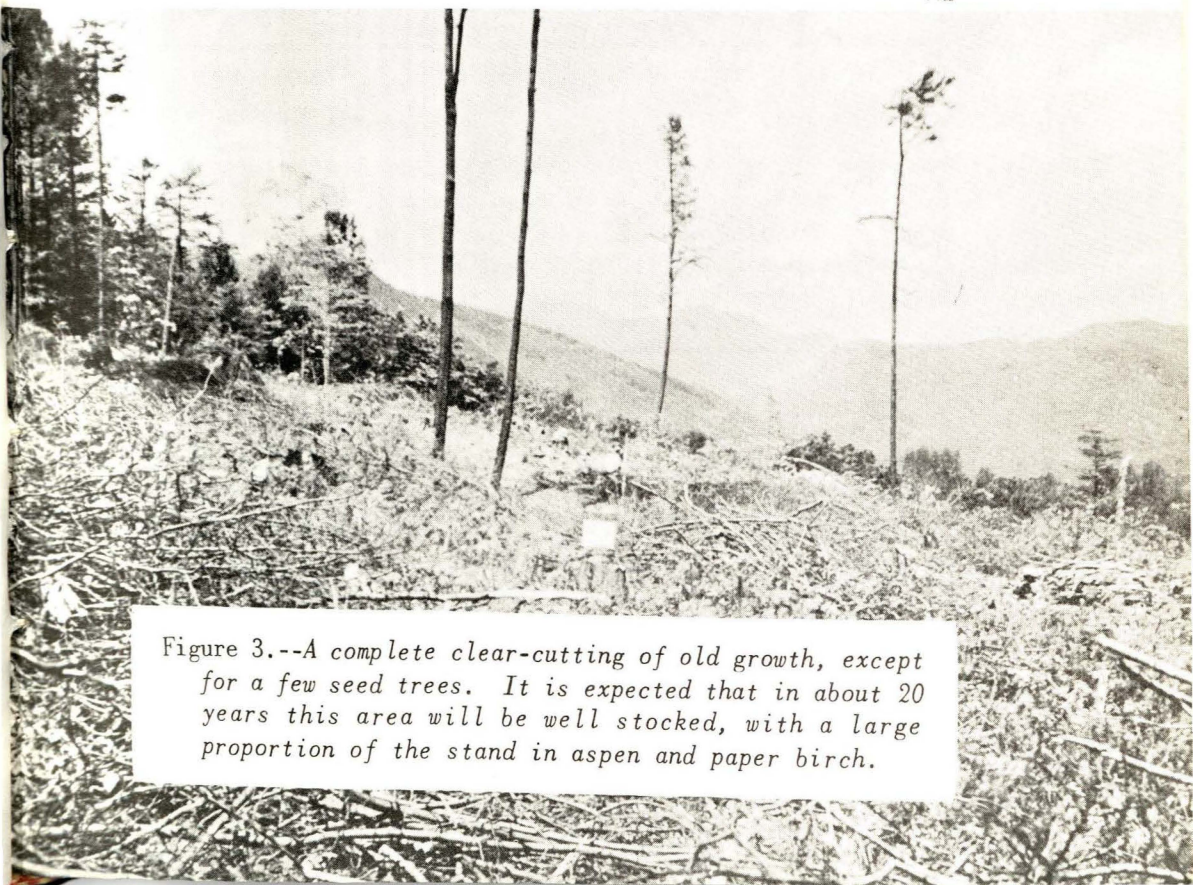


Figure 3.--A complete clear-cutting of old growth, except for a few seed trees. It is expected that in about 20 years this area will be well stocked, with a large proportion of the stand in aspen and paper birch.

the need for regeneration of certain species. The selection system will find the most general use, with occasional patch cuttings where the trees to be removed occur in groups. The need for clear-cutting is least frequent.

STOCKING, STRUCTURE, AND GROWTH

Regardless of product objectives, hardwood forests will always produce much material suitable only for pulpwood and other bulk products. When the old-growth forest is put under management, the first cuts usually will be low in value because of cull and poor quality. Even later, when the forest is on sustained yield under some uneven-aged silvicultural system, there will be periodic harvests of smaller trees. And upper sections of sawlog trees will continue to be lower in quality than butts. Therefore, one cannot

Table 2.--Estimated residual structure and growth goals per acre¹
for uneven-aged northern hardwoods managed for
high-valued products

Diameter class & group	Stand and stocking		Estimated annual production, ² basal area ³	Estimated allowable cut in 10 years	
	Trees	Basal area			
	Number	Sq. ft.	Sq. ft.	Cu. ft.	Bd. ft.
6	25	5	0.13	26	--
8	20	7	.18	36	--
10	15	8	.21	42	--
12	12	9	.23	58	276
14	10	10	.23	58	276
16	8	9	.23	58	276
18	6	9	.22	55	264
20	4	8	.21	52	252
22	3	8	.19	48	228
24	2	7	.17	42	204
Total	105	80	2.00	475	1,776
6-10	60	20	0.52	104	--
12-16	30	28	.69	174	828
18-24	15	32	.79	197	948
Total	105	80	2.00	475	1,776

¹This desired stocking and structure after each cut represents the average acre. It is not expected that each acre will ever conform rigidly to these goals.

²Production is the net change in volume. It is the growth of all trees of measurable size present after cutting, minus mortality, plus ingrowth.

³As rough conversion factors for pole timber, we use 5 square feet of basal area for a rough cord and 20 cubic feet for a square foot. For sawtimber, we use 4 square feet of basal area per cord, 25 cubic feet per square foot of basal area, and 120 board-feet per square foot.

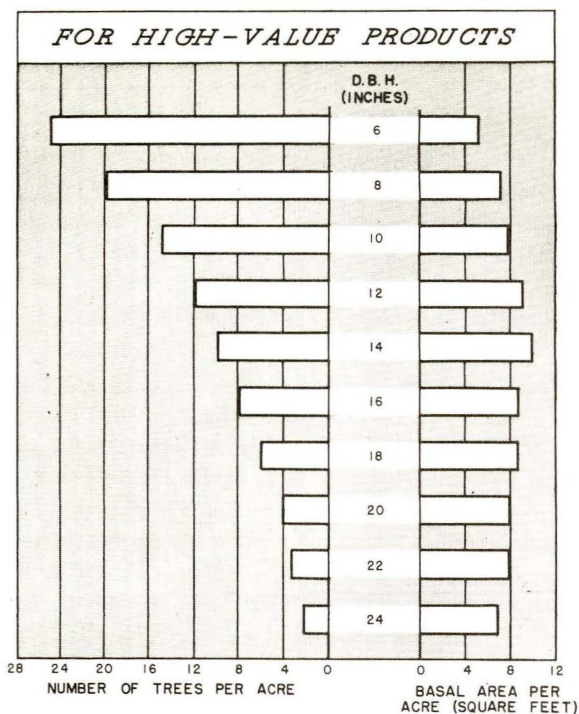


Figure 4.--Suggested stand and stocking for uneven-aged northern hardwoods after each cutting, for high-value products.

manage only for high-value material such as veneer and saw logs. Management goals must be consistent with (1) the characteristics of the species, (2) the sites upon which they grow, and (3) the systems of silviculture for which they are suited.

High-Value Products

Hardwoods on average-to-better sites that are reasonably accessible can be managed primarily for high-value products. In uneven-aged forests, the largest yields of high-value products are associated with relatively large volumes per acre. This is so because a large proportion of the growing stock is in large trees (5). This in turn means fewer trees to the acre (table 2).

Table 3.--Estimated residual structure and growth goals per acre¹
for uneven-aged northern hardwoods managed for bulk products

Diameter class & group	Stand and stocking		Estimated annual production, basal area ²	Estimated allowable cut in 10 years	
	Trees	Basal area			
	Number	Sq.ft.	Sq.ft.	Cu.ft.	Bd.ft.
6	50	10	0.29	58	--
8	30	11	.32	64	--
10	20	10	.32	64	--
12	12	9	.28	70	336
14	8	8	.24	60	288
16	6	7	.20	50	240
18	4	5	.15	38	180
Total	130	60	1.80	404	1,044
6-10	100	31	0.93	186	--
12-14	20	17	.52	130	624
16-18	10	12	.35	88	420
Total	130	60	1.80	404	1,044

¹This desired stocking and structure after each cut represents the average acre. It is not expected that each acre will ever conform rigidly to these goals.

²See table 2, footnotes 2 and 3.

To manage for these products, we recommend a stocking of about 80 square feet of basal area per acre after cutting, in trees from 5.0 to 25.0 inches d.b.h. (table 2 and fig. 4). This corresponds to about 1,900 cubic feet per acre, to a flexible 4-inch top diameter.

In table 2, we have used three diameter groups, based upon 2-inch d.b.h. classes. If other diameter groupings are desired, the required numbers of trees can be read from the table. Regardless of existing stocking, the greatest potential lies in the large sawtimber group. Only a few trees in the middle group will make Factory Grade 1 logs (8).¹

Growth estimates, drawn from experience at Bartlett, indicate the volumes and sizes of trees expected to be available for subsequent cuts under similar conditions. In

¹This refers to U.S. Forest Service hardwood log grades for standard lumber. In general, No. 1 logs will yield from 64 to 80 percent No. 1 common and better lumber; No. 2 logs, 40 to 64 percent; No. 3 logs, 13 to 36 percent. The variation is due chiefly to differences in species and log diameters.

addition to growth, the allowable cut depends upon the length of the cutting cycle.

We recommend cutting cycles of 10 to 20 years for most conditions. Present stocking, accessibility, markets, and volume all influence the length of cutting cycle. With cycles longer than 20 years, however, there is less control over growth rate, mortality, cull, and reproduction.

We do not mean that every acre must have the desired stocking and structure. These goals may not be approached for several cutting cycles. But when most acres in the forest come close to this stocking and structure, it will be possible to have stable, sustained cuts. And most of the allowable sawtimber cut will come from larger trees.

Of course, species is at least as important as tree size in determining product values. Within the limits of the desired stocking and structure, the forester can mold the species composition over several cuts by his cutting and cultural practices. In the uneven-aged forests, we want to maintain or increase the proportions of yellow birch, sugar maple, red spruce, and hemlock.

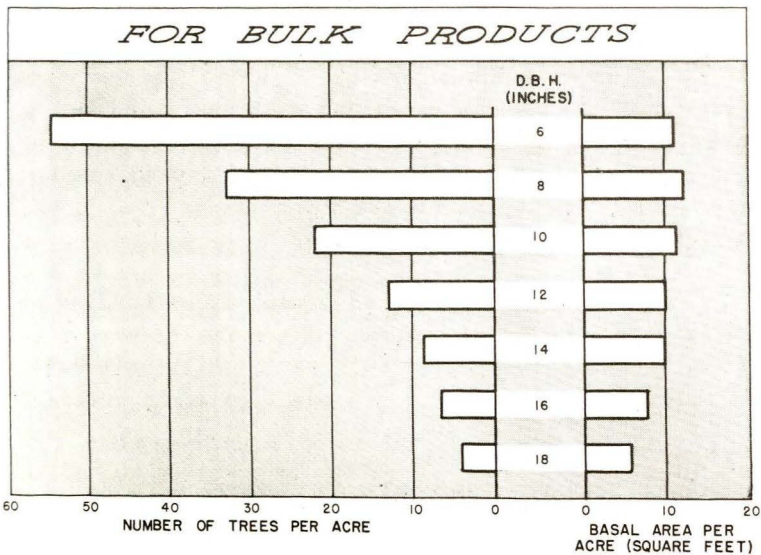


Figure 5.--Suggested stand and stocking for uneven-aged northern hardwoods after each cutting, for bulk products.

*Bulk
Products*

On poorer sites, hardwoods should be managed primarily for bulk products; but even on the better sites some owners may prefer to manage for such products. Poorer sites are generally drier or close to the upper limits for hardwood timber on mountain slopes. There are no definitive hardwood-site-productivity data for this region. Still, we can assume that on poorer sites the mature hardwoods average less than 30 feet in merchantable height to a 4-inch top.

For bulk products we recommend a stocking of 60 square feet of basal area after cutting in trees 5.0 inches to 18.0 inches d.b.h. (table 3 and fig. 5). With this stand structure and level of stocking, much growth will be in pole-timber, and most products cut will be small. In general, cutting cycles will be 20 years longer.

Second-Growth Forest

SECOND GROWTH forests have a smaller range of size classes than old growth. But quality may vary as widely. Some stands may be filled with aspen and red maple sprouts; others will contain a high proportion of paper birch and white ash. Among the second-growth hardwoods, white ash and paper birch are most desired, with yellow birch and sugar maple next in rank.

Second-growth forests will usually be handled by an even-aged silvicultural system. Since the trees are young and small, and mature relatively early, silvicultural systems must be concerned with reproduction after cutting.

SILVICULTURAL SYSTEMS

*Clear
Cutting*

Based upon observations at Bartlett (10) and elsewhere in New England, the practice of clear-cutting extensive

Figure 6.--A clear-cut patch in a 60-year-old even-aged stand. Such patch cuttings should increase yellow birch regeneration.



areas of second growth may not provide satisfactory reproduction. Often, such cutting is followed by raspberry, blackberry, and pin cherry. When that happens, it may be many years before merchantable tree species take over. At least, this appears true now where stands under 60 years of age have been clear-cut on areas larger than 1 acre.

Though these observations are not backed up by experimentation, there is little doubt about the results of successive clear-cuttings of young, even-aged stands in New York and Pennsylvania. They have led to stand deterioration: less desirable species, more sprout growth, smaller yields, and a general lowering of stand quality.

Clear-cutting of strips not more than 2 chains wide or in patches of less than 1 acre in area may be successful in obtaining reproduction of desirable species (fig. 6).

Instead of a single clear-cutting in the young second-growth forest, there may be one or more interim cuts before rotation age is reached (9). These operations would be a combination of improvement and harvest cuts. This is so because of the early silvical and economic maturity of aspen, paper birch, and white ash.

Aspen tends to break up at age 50. Paper birch may be ripe at 60 years. After 70 years, it will begin to deteriorate, and the ratio of desirable sapwood will decrease. Probably ash will have accumulated its maximum of valuable sapwood at 80 years. Thus, depending upon the age and composition of the stands, any interim cuts will include a harvest of one or more of these short-lived species. At the same time, for improvement cutting, the forester may mark red maple sprout clumps and beech and sugar maple stems of low vigor or quality.

As a result of this type of operation, stand density is reduced, the crown canopy is broken, and reproduction develops. Then, when the stand reaches 80 years or older, the overstory can be removed by a series of clear-cuts. As in the old-growth forest, the composition of the resulting stand will be influenced by that of the overstory at the time of the final clear-cut, the advance growth, and the sizes of the openings (4).

Selection

System Cutting

The forester has an alternative to the even-aged system of silviculture represented by clear-cutting and shelterwood cutting: if willing to move toward the classic climax type of birch-beech-maple, he may cut under the selection system. After several selection cuts in second-growth forests, the proportion of more tolerant hardwoods should have increased (9). With continued cutting under the selection system, structure will change from even-aged to uneven-aged.

In deciding upon a system of silviculture for the second-growth hardwood forest, the desired composition of the regeneration is the prime consideration. The various types of clear-cutting--blocks, strips, patches, shelterwood--will favor the less tolerant ash and birches. The selection system favors sugar maple, beech, and hemlock.

TENDING THE STANDS

In addition to manipulation of merchantable cuts, the forester has a number of silvicultural tools for improving young even-aged forests. These tools or treatments--chiefly cleanings and thinnings--are used to increase timber quality

and value yield during the rotation. In some cases, the results are indirect. Often they do not show for many years, thus making the treatments difficult to evaluate.

Cleanings

Cleaning is an operation in which undesirable members of juvenile or sapling stands are removed (7). These include trees of unmerchantable or low-value species, forked or crooked trees, and stump sprouts in the main crown canopy. We have no experimental data on the net benefits of cleaning young hardwood stands. It seems obvious that, in the long run, cleaning should appreciably increase stand value--but we don't know how much. At present, we recommend cleaning to those who are willing to invest in bringing through to pole size maximum numbers of saplings of desired species and form.

Cleanings should be begun when the trees are head high--no more than 10 years of age--and should be continued until the trees reach pole size. Cleanings should be so light that it is difficult to see that the stand has been touched, and should be restricted to the main crown canopy. Sapling stands always should be dense enough to ensure self-pruning of lower limbs, straightness of bole, and a minimum of snow and ice damage. Cleanings should be repeated as often as needed to maintain a healthy, vigorous stand of desirable stems.

Removal of sapling aspen and pin cherry may not be necessary. The foliage of aspen and pin cherry is light enough not to unduly hinder the growth of other species. Pin cherry dies out of the stand at an early age. And there may be markets for the larger aspen, which would then be the first crop.

Thinnings

Most young, even-aged northern hardwood stands can benefit from judicious thinning. While there are several methods of thinning, crown or crop-tree thinnings seem best for these stands (1). In general, the time to start thinning is as soon as crop trees can be recognized. Stands of intolerant species, such as paper birch, should be thinned earlier than those of tolerant species. Before age 40, paper birch and white ash may respond to thinning, but according

to our data they do not respond after age 60. Sugar maple and the other tolerant species, however, will respond even after age 60.

In a crop-tree thinning, only trees that are interfering with the crown development of crop trees are removed. Still, typical stands contain poor growing stock in the main crown canopy that may not be in the way of the crop trees. They may be cut if²:

- Growth will be shifted to better trees, or
- They may not live to the next thinning, or
- The stand will not be opened excessively, or
- The reduction in stand density will facilitate regeneration later.

Although precise stand-density guidelines are not available, thinnings should be heavy enough to ensure a steady increase in the volume and value growth of the better trees in the stand. Indications are that it is best to thin lightly and often; intervals of 10 to 15 years in northern hardwoods should give the forester reasonable control over the stand's development. Excessive opening of the crown canopy may result in a "feathering out" of the trees, with a possible loss of value. Yellow birch is especially sensitive to excessive crown openings.

Should the thinning pay for itself? Since the trees removed will be small or rough, their value will be low. A more critical question is: "Will the increase in value yield during the rotation, as compared to an unthinned stand, be more than enough to pay for the thinnings?" This must be answered on the land itself; but if the work is well-timed and well-done the answer should be "yes".

Red maple sprout clumps are often a problem. At Bartlett, we have tried cutting one or two sprouts from a clump. But growth did not increase on the remaining sprouts, and heart rot spread to some of them. Now, we advise cutting the entire clump. Silvicides can be used to prevent resprouting. Large hold-overs can be removed with the thin-

²From lecture notes of Hans Leibundgut, professor of silviculture at the Swiss Federal Institute of Technology, Zurich, Switzerland.

nings or they can be girdled or poisoned in a separate operation.

Thinnings recommended here are not to be confused with the interim cuts in second-growth stands mentioned earlier. Here, we are dealing with a planned series of cuts aimed at increasing the total volume and value yield of the stand during the rotation (2).

ROTATION AND STOCKING

Product objectives for the second-growth northern hardwood forest may be quite flexible. They are a function of species composition, growing stock level, length of rotation, and owner preference.

High-Value Products

Even-aged, second-growth forests, especially those on good sites, can yield high-value products. Where the species are mostly yellow birch, beech, and sugar maple, high-value yields will be associated with long rotations (100 to 120 years) and a high level of stocking after thinning (80 square feet of basal area), with fewer trees to the acre as rotation age approaches (6). Stands that contain a high proportion of the less tolerant species--aspen, red maple, paper birch, and white ash--can be managed on an 80-year rotation at about 70 square feet of basal area per acre after each thinning. Most of the white ash would be held for the final cut.

To realize maximum values from second-growth stands, there would have to be a series of thinnings and improvement treatments before the harvest cuts. In some stands, these thinnings would include a harvest cut of paper birch and white ash, which often make furniture squares and handle stock.

We have yet to carry a stand at the Bartlett through a rotation with a high-value product objective. However, this has been done so often and so successfully with beech and oak in Denmark, France, Germany, and other countries, that it should be possible in New England.

Bulk Products

The objective here is maximum volume yields of such products as pulpwood, chemical wood, and fuelwood. Thinning would serve only to harvest trees that would otherwise die, or to maintain most of the volume in trees of at least minimum merchantable size. Since bulk products commonly are low in value, investments in cultural practices must be kept low. In general, poorer sites and less accessible areas would be managed for bulk products. For these sites and this product objective, we recommend a stocking of 60 square feet of basal area per acre with a 60-year rotation.

General Remarks

IN general, previously unmanaged northern hardwood forests in New England can be divided into two types: old growth and second-growth. Each calls for different treatment.

As old-growth is put under management, it will probably be converted to a balanced, uneven-aged forest. Flexible methods are suggested for converting the old-growth forest to this managed state and holding it there. The suggested maximum diameters are not meant to be taken as the last word. Should a stand contain larger, high-value trees that are thrifty, it would be unwise to liquidate all of them at once. Other stands may not have any trees larger than 20 inches. It would take many years to raise their maximum diameter 4 inches. In balanced, uneven-aged forests, a change in the upper-diameter limit of only 2 inches has a profound effect upon the total volume and, perhaps, upon the quality of the trees.

As second-growth is put under management, it will usually become an even-aged forest. But, the concept of a rotation in northern hardwoods is not hard and fast. For the first 40 or 60 years, there will be a narrow range of ages and diameter classes. Skillful management will include thinnings, and harvesting of early-maturing species. Thus, with increasing age, the composition will include more of

the tolerant species with a greater range of sizes. And, there will be advance reproduction of the tolerant species. For long rotations this means that as liquidation-age nears, the forest will look less even-aged. The forester working with short rotations probably will not run into this situation.

We have assumed that the general precepts of good forest management will be followed. This means adequate protection, recognizing multiple-use values, and dividing the forest into compartments or chances with permanent boundaries; it is important that the boundaries be permanent. Product objectives, stocking and structure goals, and growth volume measurements will all be on a compartment basis. This applies also to records, without which there can be no purposeful forest management.

Now, in managing the compartments to conform to objectives, the forester may treat several different stands within the compartment. In other words, concepts such as stands, patches, openings, and strips are related to the silvicultural tools that the forester uses in managing the compartment and the forest. For small ownerships, the compartment and the forest may be one. But the guiding principles are the same.

The suggestions made here are for general forest conditions. Smaller areas (such as woodlots) that are more accessible and closer to good markets, may be managed more intensively than larger, more remote forests. This means shorter cutting cycles, more growing stock per acre, and more timber-stand-improvement activities.



Literature Cited

1. Hawley, Ralph C., and Smith, David M.
1954. The practice of silviculture. Ed. 6.
525 pp., illus. New York.
2. Heiberg, Svend O., and Haddock, Philip G.
1955. A method of thinning and forecast of yield in
Douglas fir. Jour. Forestry 53: 10-18.

3. Jensen, Victor S.
1943. Suggestions for the management of northern hardwood stands in the Northeast. Jour. Forestry 41: 180-185.
4. Leak, William B., and Wilson, Robert W., Jr.
1958. Regeneration after cutting of old-growth northern hardwoods in New Hampshire. Northeast. Forest Expt. Sta., Sta. Paper 103. 8 pp.
5. Meyer, H. Arthur.
1952. Structure, growth, and drain in balanced, uneven-aged forests. Jour. Forestry 50: 85-92.
6. Moller, Carl Mar, et al.
1954. Thinning problems and practices in Denmark. Edited by Svend O. Heiberg. State Univ. N. Y. Coll. Forestry Tech. Bul. 76. Syracuse. 92 pp.
7. Schaedelin, Walter
1942. Die Auslesedurchforstung. 147 pp., illus. Berne, Switzerland.
8. U.S. Forest Products Laboratory.
1953. Hardwood log grades for standard lumber. Proposals, and results. Forest Prod. Lab. Rpt. D1737. 15 pp.
9. Wilson, Robert W., Jr.
1953. How second-growth northern hardwoods develop after thinning. Northeast. Forest Expt. Sta., Sta. Paper 62. 12 pp.
10. ----- and Jensen, Victor S.
1954. Regeneration after clear-cutting second-growth northern hardwoods. Northeast. Forest Expt. Sta. Forest Res. Note 27. 3 pp.

SOME SUGGESTED READING

- Arbogast, Carl, Jr.
1953. Managing northern hardwoods in the Lake States. Lake States Forest Expt. Sta. Misc. Rpt. No. 23, 11 pp.
- Eyre, F.H., and Zillgitt, W.M.
1953. Partial cuttings in northern hardwoods in the Lake States. Lake States Forest Expt. Sta. Tech. Bul. No. 1076, 124 pp.
- Gilbert, Adrian M.
1954. What is this thing called growth? Northeast. Forest Expt. Sta., Sta. Paper No. 71, 5 pp.
- Wilson, Robert W., Jr., and Hutnik, Russell J.
1955. Growth behavior of northern hardwoods after a partial cutting. Jour. Forestry 53: 488-492.

